Traffic Engineering & Highway Safety Bulletin

Military Surface Deployment and Distribution Command Transportation Engineering Agency

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Sign Retroreflectivity

Did You Know...

- The highway fatality rate per mile of travel is **three times higher at night** than during the day.
- Traffic signs need to be **retroreflective**, which is the unique ability to reflect light back toward the light source.
- To improve nighttime safety, **minimum levels** of retroreflectivity for traffic signs will be established by the Secretary of Transportation.

IN THIS ISSUE:

Traffic signs need to have adequate *retroreflectivity* to properly guide and protect personnel and visitors who are traveling at night on military installations. It is a safety and liability issue, and the minimum requirements are becoming more stringent.

Research clearly documents the need to use "brighter" signs due to changes in headlight design, the higher seating position in the popular SUVs, and the aging population.

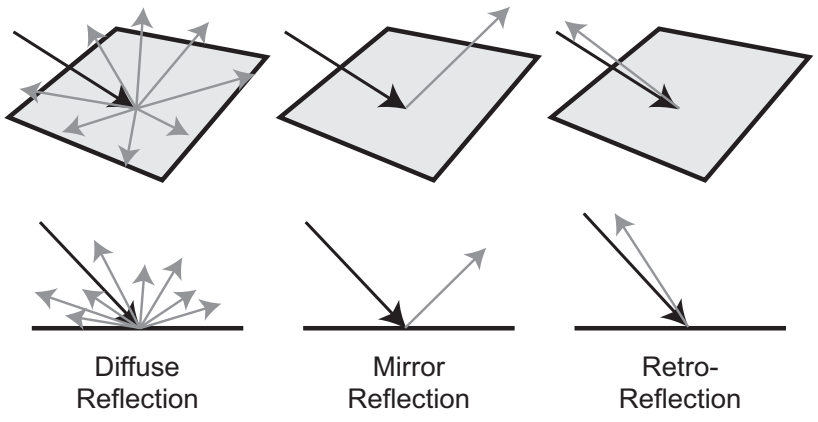
Managing a sign replacement program is extremely important, and it may be easier than you think.

What is Retroreflectivity?

Most objects reflect light. The most common type of reflection is "*diffuse reflection,*" where light scatters after striking rough surfaces such as trees, clothing, and carpet. Only a very small amount of the diffused light reflects back toward the light source.

Another type of reflection is "*mirror reflection*" that occurs when light strikes smooth or glossy surfaces, and the light reflects off the surface at an equal but opposite angle. Mirror reflection frequently occurs at night on wet roads when the headlights of approaching vehicles create extensive glare.

In contrast, "*retroreflection*" is the unique ability of a surface to reflect light back toward the light source, and "retroreflectivity" is that measurable property of a material.



Why is Retroreflectivity Important?

The nighttime visibility of signs and pavement markings is essential for highway safety. National studies show that about **50 percent of all fatal crashes occur at night** despite lower travel volumes. In fact, the average fatality rate (fatalities per 100 million vehicle-miles of travel) is about three times higher during the night than during the day.

Factors that contribute to higher nighttime crash rates include:

- After age 20, our eyes need twice as much light approximately every 13 years in order to read (e.g., a 33-year old needs two times more light, a 46-year old needs four times more light, and a 59-year old needs eight times more light).
- Fewer visual clues that delineate the roadway alignment at night.
- Glare from opposing traffic further reduces the number of visual clues.
- Rain, snow, fog, dew, and frost reduce visibility.
- More intoxicated and sleepy drivers.

Although it is possible to illuminate signs and markings, the most efficient method is to use headlight illumination and retroreflective materials.

Some traffic signs may look almost new during the day but are completely ineffective at night. This nighttime visibility problem is usually a function of the type and age of the retroreflective material.

Section 2A.08 of the *Manual on Uniform Traffic Control Devices* (*MUTCD*) requires all regulatory, warning, and guide signs to be retroreflective or illuminated to show the same shape and a similar color both day and night. However, minimum retroreflectivity values were never established.

Because of nighttime safety concerns, in 1993 Congress directed the Secretary of Transportation to revise the *MUTCD* to include minimum levels of retroreflectivity. Since that time, extensive research was completed and the Secretary published proposed minimum values. If adopted, the proposed values will require major changes.

Making Signs Retroreflective

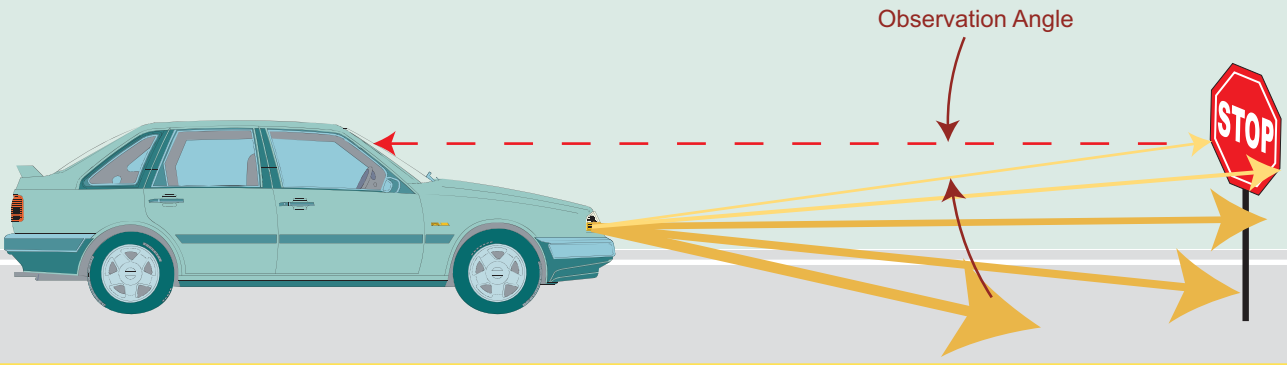
It is extremely important for drivers to have signs "light up" and become visible under headlight illumination. To accomplish this, sign manufacturers apply a "retroreflective material" to the face of each sign that either contains microscopic glass beads or cube corner reflectors.

If they could make all glass beads and cube corner reflectors perfectly shaped, all reflected light would return directly to the light source (headlights). Although we do not have perfectly shaped lenses, drivers do see more reflected light the closer their eyes are to the headlights. The angle formed between the headlights, the sign and the driver's eyes is the observation angle.

Retroreflective materials are also more efficient when the light source is approximately perpendicular to the sign face; therefore, it is important to have signs oriented to face approaching traffic.

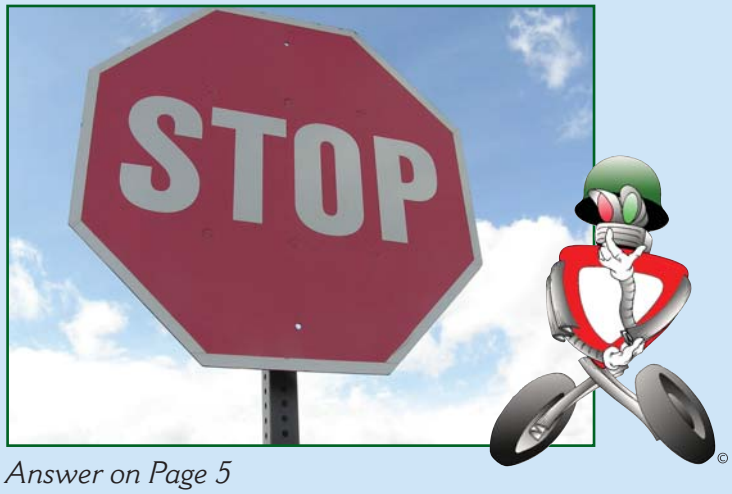
The ability to see traffic signs at night is a function of the following:

- Driver's night vision.
- Intensity and light distribution of the headlights.
- Distance, mounting height, and orientation of the sign in relation to the vehicle's headlights.
- Location of the driver's eyes with respect to the headlights.
- Type, color and age of the retroreflective material.



A retroreflectometer measures retroreflectivity. Hand-held instruments cost about $8,000 and measure the retroreflectivity at preset angles to simulate what a driver sees. To take a reading, the operator must accurately position the instrument against the sign face and pull the trigger. Because signs may be 7 feet or more above the ground, this is a time-consuming and difficult task.

Is Anything Wrong With This Stop Sign?



Answer on Page 5

What Types of Retroreflective Materials are Available?

Initially, only one type of retroreflective material was available for traffic signs, but as technology developed, brighter and more durable retroreflective materials became available. **Table 1** identifies eight types, or grades, of retroreflective materials currently available for permanent-type signs.

One of the reasons that higher grades of retroreflective materials are essential today is because the low beam headlights on newer vehicles do not provide as much upward light as the older type headlights. The vehicle manufacturers initiated a change to visually/optically aimable (VOA) headlights to reduce the irritating glare caused by oncoming headlights, but theses newer headlights also reduce the amount of light on signs, especially those installed over the roadway.

Another reason signs need better retroreflective materials today is due to the popularity of SUVs. Because the driver of a SUV sits at a greater height above the headlights than the driver of a passenger car does, the observation angle is greater and the SUV driver sees less reflected light than the driver of a passenger car would see. Drivers of large trucks see even less light.

The retroreflectivity of new Type III materials is about four times brighter than new Type I materials. Moreover, because Type I materials deteriorate much faster than Type III materials, after 7 years the Type III materials will be about six or seven times brighter.

Table 1. Available Types of Retroreflective Materials

Type Retroreflective Material*	Common Name	Life Expectancy (years)	Comments
I	Engineering Grade	7	These two types are not recommended.
II	Super-Engineering Grade	7-10	
III & IV	High-Intensity or High-Performance Grades	10+	Recommended material, except use a higher type material for all white legend on overhead signs.
VII, VIII, IX & X	Super-High Intensity or Very High-Intensity Grades	10+	Microprismatic materials.

*Two types classified by ASTM D4956 are not included in this table: (1) Type V material, which is used for delineation; and (2) Type VI material, which is used for roll-up signs in work zones.

Photos showing the difference between Type I (top) and III (bottom) retroreflective materials

Because the proposed minimum retroreflectivity values are high, even new signs made with Type I and Type II materials cannot meet some of the proposed values. However, studies show that the longer-lasting, more expensive Type III materials are more cost effective. Therefore, military installations should no longer use any Type I (Engineering Grade) or Type II (Super Engineering Grade) materials.

Type I and II materials both have a uniform appearance similar to metallic paint, whereas all Type III, IV, VII, VIII, IX, and X materials have a pattern of hexagons, diamonds, or circular shapes measuring about one-eight inch across. Therefore, it is easy to recognize the inferior Type I and II materials.

How to Ensure Adequate Retroreflectivity

- Obtain all signs from a reputable sign shop.
- Specify a minimum Type III retroreflective material for all signs.
- Require Type VII, VIII, IX, or X material for white legends on all overhead guide signs.
- Annually inspect signs at night to ensure they are visible and performing properly, and replace damaged or missing signs.
- Replace all signs at intervals based on the sheeting manufacturer's warranty.

Manufacturers of Type III and higher types of retroreflective materials typically guarantee their materials at a very high retroreflectivity level for 10 or more years. Since the guaranteed retroreflectivity values are significantly greater than the proposed minimum values, Type III and higher types of materials should exceed the manufacturer's warranty, even under the harshest field conditions (signs that face south and signs exposed to high temperatures, high humidity, and/or high elevation).

Special inks are required on all retroreflective materials. In addition, all colored inks need to be a transparent-type ink applied at the proper thickness over white retroreflective material so that the color is correct and the sign is visible at night. Therefore, it is essential to obtain all signs from a reputable sign shop.

When Do I Replace the Signs?

Table 2 (on page 5) shows six methods to manage a sign replacement program. There are advantages and disadvantages of each approach, but since military installations do not have trained sign inspectors or retroreflectometers to evaluate retroreflectivity, only Methods 2 and 3 are viable at this time.

Installations are encouraged to replace all signs at the same time as shown in Method 3. This "blanket approach" will typically reduce labor costs and help ensure a uniform appearance of the signs.

For example, if in 2007 you replace all traffic signs with new signs made with a Type III material having a 10-year warranty, then you can feel confident that your next replacement program does not need scheduled until 2017.

By replacing all of the signs at the same time, an installation eliminates the need to track and monitor individual sign replacement dates. However, it is always a good idea to do a drive-by sign inspection on a regular basis to ensure that the signs exist, and that they are properly oriented. The best time for these reviews is at night, because nighttime reviews can also help identify problems caused by lights or other visual distractions.

Answer from Page 3

This STOP Sign looks almost new and it is perfect during the day, but it is not retroreflective at night. This illustrates the importance of getting signs from a reputable sign shop.

Table 2. Sign Replacement Programs

Methods	Advantages	Disadvantages
1. **Nighttime Visual Inspection:** Annually inspect all signs at night by a qualified sign inspector, from a moving vehicle using low beams, and replace defective signs. This is the "*calibrated eye*" approach.	* Helps evaluate sign orientation and competing lights	* Requires a trained, nighttime sign inspector * Requires an annual review * Encourages the mixing of old and new signs
2. **Manufacturer's Warranty:** Annually replace signs based on the age of each sign and the sheeting manufacturer's warranty.	* Simple	* Requires a good inventory * Requires an annual review * Encourages the mixing of old and new signs
3. **Manufacturer's Warranty with Blanket Replacements:** Replace all signs at the same time based on the sheeting manufacturer's warranty.	* Simple * Reduces the mixing of old and new signs * Low total program cost	* May prematurely replace some signs installed during intervening replacement cycles (e.g., those replaced due to vandalism, crashes, etc.)
4. **Measured Sign Retroreflectivity:** Annually measure retroreflectivity of individual signs with a retroreflectometer, and replace those that are defective.	* Precise	* Requires a retroreflectometer * Very time-consuming * Requires an annual review * Encourages the mixing of old and new signs
5. **Control Signs:** Annually replace signs based on the age of each sign and the retroreflectivity readings of a few control signs. Control signs should face south to maximize the sun exposure, and should include signs of every color combination.	* Similar to Method 2, but should result in longer sign life and lower total cost	* Requires a retroreflectometer * Requires a good inventory * Requires an annual review * Encourages the mixing of old and new signs
6. **Control Signs with Blanket Sign Replacement:** Replace all signs at the same time based on the retroreflectivity readings of a few control signs. Control signs should face south to maximize the sun exposure, and should include signs of every color combination.	* Similar to Method 3, but should result in longer sign life * Reduces the mixing of old and new signs * Lowest total program cost * Ideal method for large highway agencies	* Requires a retroreflectometer * May prematurely replace some signs installed during intervening replacement cycles (e.g., those replaced due to vandalism, crashes, etc.)

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